FUSION facts

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A. WHAT FUSION THEORY MUST EXPLAIN

WHAT FUSION THEORY MUST EXPLAIN
by Dr. Samuel P. Faile and Hal Fox.

Excellent scientific work is being done to prove the reality of cold fusion. As aptly put by Texas A and M scientists "We are aware that, according to the classical theory of nuclear physics, when D-D fusion occurs, the rate of neutronproduction should be approximately equal to that of tritium. This is not observed in the present experimental program. We believe that it is important firstly to establish the facts about tritium production on electrodes. The theory of electrochemical confinement will be discussed elsewhere." [1].

The purpose of this article is to discuss the various scientific observations that have been made in support of solid-state fusion that should be explained by any comprehensive theory.

NEUTRON PRODUCTION FROM DUETERATED CRYSTALS

Neutrons have been shown to be generated when deuterated dielectrics are fractured. Deryagin,' et al [2] reported in 1985 the production of neutrons when heavy ice D20 was fractured. In 1989 the same scientists reported the production of neutrons from the fracture of titanium [3].

NEUTRON PRODUCTION INCREASE IN LIQUID NITROGEN

Neutron production is shown to increase when experiments are cooled in liquid nitrogen [3].

NEUTRON PRODUCTION IN ELECTROCHEMICAL CELLS

Many scientists have shown that neutrons are produced in an operating electrochemical cell. Fleischmann and Pons [4] observed neutrons above background with the use of inadequate equipment and later withdrew the results. Wolf, et al [5] not only measured neutrons but later has showed

that some degree of control can be exercised over the nuclear reaction that produces neutrons (personal communication). Jones, et al have firmly established that cold fusion exists in metal lattices in electrochemical cells solely on the basis of the measurement of neutrons
[6].

The theory mayhave to accommodate the possibility of large amounts of thermalized neutrons which are quickly absorbed by various isotopes such as Lithium 6. How could the neutrons be involved in a reaction while avoiding a history where high kinetic energy neutrons are produced? Would a catalyst be neededto cause a transfer without high speed particle production?

TRITIUM PRODUCTION

Many workers in the field have measured tritium being produced by nuclear reactions in electrochemical cells. The first report was from Fleischmann, Pons, and Hawkins [4]. This report was further substantiated by Wolf, et al [5] and more thoroughly by Packham, et al [1]. Others who have measured tritium are Iyengar [7] and Sanchez [15].

There is a need to explain how, in some instances, the tritium to neutron ratio can be as high as 10^8. If the tritium were produced in an energetic state of say 1 MeV of kinetic energy, one would expect non-thermal neutrons from tritium plus deuterium reacting to form alpha particles and neutrons (t+ d -->4He + neutron).

EXCESS HEAT

At least two nuclear reactions that are occurring in the electrochemical cells have been widely demonstrated by the measurement of nuclear byproducts of neutrons and tritium. These two reactions are:

1. *D* + *D* ---> 3He + neutron + energy
2. *D* + *D* ---> T + proton + energy

As mentioned by Fleischmann, et al [4] "The most surprising feature of our results however, is that reactions (1) and (2) are only a small part of the overall reaction scheme and that the bulk of the energy release is due to an hitherto unknown nuclear process or processes (presumably due to deuterons)."

Many other scientists, including Oriani, et al [8] have shown that there are significant amounts of excess heat that have been measured. Others that have measured excess heat are Huggins [9], Appleby [10], and Noninski [14].

The theory needs to explain how excess heat can be produced over long time periods without the measurement of the expected tritium or neutron byproducts.

A theory needs to explain how one avoids the internal nuclear transformations which produce gamma radiation. Is there a new quantum mechanical process that dissipates the high energy of a fused product to a dynamic collective wave of deuterons or electrons?

There is a need to explain the sporadic heat effects. Are there surface effects? Does the buildup of a fusion product de-tune a resonance mode? Could the charging help release a neutral particle catalyst? Then after heat is produced for some period of time, does the reaction by-products of the process change the nature of the catalyst or lattice such as by producing carbon?

CELL CONFIGURATION FOR SELECTED NUCLEAR REACTIONS

It has been reportedly Dr. Kevin Wolf (personal communication) that the use of platinum anode seems to favor neutron production -- reaction (1) ′- while the use of a nickel anode seems to favor tritium production ′reaction (2).

In addition, Dr. Wolf has observed that for a specific configuration of electrochemical cell (in which neutrons were being measured) that increasing the current above 150 mA/cm sq through the palladium cathode stopped the production of neutrons.

Dr. Glen Schoessow has been quoted as claiming to be able to control the nuclear reactions in a fusion electrochemical cell.

The theory of nuclear fusion, as it develops, will be expected to explain these observed phenomena. In addition theory should explain how to trigger the onset of bursts of energy or of the onset of excess heat production.

NUCLEAR REACTIONS IN TITANIUM

Several scientists have found that titanium, after being loaded with deuterium gas, will produce neutrons or show bursts of neutron production. Reference [3] involves fracturing the titanium. Ninno, et al [11] performed experiments in which titanium was loaded with deuterium gas at about 50 atmospheres pressure, cooled to liquid Nitrogen temperatures and allowed to warmup. Iyengar [7] reports on loaded titanium disks placed between sheets of X-Ray film where the tritium formation and decay exposed the film. Sanchez [15] reports neutrons and tritium produced by Ti in an electrochemical cell.

The theory will need to explain why the neutron production occurs sporadically and is a function of chilling and warming.

NUCLEAR REACTIONS INVOLVING LITHIUM

Dr. Appleby aptly characterizes the experiments as "on palladium and deuterium in the presence of lithium." In [10] Appleby, et al report an experiment in which sodium deuteroxide is used to replace lithium deuteroxide in a fusion cell (while it is producing measurable excess heat). The results are very low (but above zero) excess heat. When the lithium deuteroxide is restored, the cell regains it production of excess heat.

Experiments are needed in which it is determined if lithium is involved in a nuclear reaction or whether lithium acts as a catalyst. The theorists will need this type of specific information to help to develop a comprehensive theory.

The theory should handle the selection of electrolytes, such as lithium deuteride for Pt and Pd cells and sodium chloride [7] or lithium sulfate [15] with titanium.

NEUTRON AND TRITIUM BRANCHING

In high-energy nuclear physics, the nuclear reactions (1) and (2) above have been observed to occur with about equal frequency. Although Oppenheimer [12] discussed the branching problem in 1935, there are many highly-trained scientists who expect to find equal branching of the two nuclear reactions in the low-energy palladium lattice.

(Note the quotation in the first paragraph). Many of the scientists who have successfully replicated the Fleischmann-Pons Effect have found that equal branching of the two deuterium reactions was not observed. In fact, experiments have demonstrated that it is much easier to build a working-fusion cell that produces tritium than to obtain neutrons.

References [4, 5, and 7] all report the unexpected results that tritium production exceeds neutron production.

TRITIUM IS FOUND IN VOLCANO GASES

The theory of cold fusion should explain the fact that tritium is found in gases from volcanoes [6].

NO REPORTS OF HELIUM IN PALLADIUM LATTICE

Further experimental verification will be required. However, at the present there are no known papers in which helium 3 or helium 4 has been found to be present in the palladium lattice or in the fusion cell electrolyte in sufficient amounts to be compelling evidence of fusion byproducts.

One case has been reported (Bockris in speech given at University of Utah) in which the level of tritium first rose and then almost exponentially decreased.

It has been suggested (Collins, personal communication) that the helium gases that may be formed from one or more nuclear reactions are being rapidly scavenged by other, as yet unreported, nuclear reactions. This may be the reason for the reduction of tritium in at least one experiment.

BURSTS OF SHORT- OR LONG-TERM HEAT

Bursts of heat have been observed by many investigators including Fleischmann, et al [4], Iyengar [7], Oriani [8], and Wadsworth [13]. These bursts of nuclear activity turn themselves "ON" and "OFF" and may last from a few minutes to several days. The effect is not as yet understood.

OTHER CONSIDERATIONS

The theory should consider the nature of the oscillations of the deuterium in the palladium lattice. The theory should explain the effect of changes in the cathode of the ratio of deuterium to palladium before the onset of nuclear reactions. In addition, if the reactions occur on the surface why does the bulk cathode need to be loaded?

A theory may have to take into account the polarization properties of deuterium and the polarization effects near the surface of a palladium rod. If heavy fusion products are found, polarization effects could play a major role in overcoming or penetrating the large coulombic barriers.

A theory may consider the possible role of phonons (acoustic oscillations) and internal lazing effects. Interactions with the zero-point vacuum fluctuations may have to be considered.

In addition to considering neutrons, protons, deuterons, tritons, and gamma radiation, a theory should indicate if a role is played by other known particles such as beta and alpha particles.

The theory may have to explain two reaction regimes where the prevailing

process would depend on chemical potential. Sometimes the heat output proceeds as low values and on occasion the metal lattice explodes or vaporizes. At high energies can there be coherent explosion effects where the energy is released in lumps of many atoms at high kinetic velocities as contrasted to heating from individual atoms.

The theory should clarify whether surface features (dendrites, deposits, "poisonings") are needed for nuclear reactions. Specifically, what surface effects are necessary for successful deuterium loading of the cathode?

Of course an excellent theory can be expected to lead to other means by which solid-state fusion reactions can be produced. In addition, it would-be helpful if the theory could help in the selection of optimum configurations (alloys) of metal lattices that would be expected to best support nuclear reactions.

SUMMARY

The above list is long but all of these observations are either well documented or are being prepared for peer review and publication. In most cases, the scientists cited are continuing their investigations and therefore the name should be used in any literature research.

To those scientists working in the new and exciting field of cold fusion, these are the facts that they and their fellow scientist shave observed. These same scientists are rapidly expanding the facts about cold fusion and related phenomena as they continue with their research efforts.

[1] N.J.C. Packham, K.L. Wolf, J.C. Wass, R.C. Kainthla, and J.O'MBockris (Texas A & M), "Production of Tritium From D20 Electrolysis at a Palladium Cathode" J. Electroanal. Chem., Vol. 270 (1989), pages 451-458.

[2] B.V. Deryagin, V.A. Kluev, A.G. Lipson, and Y.P. Toporov, "Possibility of Nuclear Reactions During the Fracture of Solids.", Institute of Physical Chemistry, Academy of Sciences of the USSR, Moscow, Translated from Kolloidnyi Zhurnal, Vol 48, No. 1, pp 12-14, January-February 1986. Original article submitted October 21, 1985. (UDC 539.375:539.1). (Includes 10 References.)

[3] B.V. Deryagin, A.G. Lipson, V.A. Kluev, D.M. Sakov, and Y.P. Toporov, "Titanium fracture yields neutrons?" Nature, Vol 341, 12 October 1989, page 492. (Includes 8 references).

[4] M. Fleischmann, S. Pons, and M. Hawkins, "Electrochemically induced nuclear fusion of deuterium." J. Electroanal. Chem., 261, pp 301-308, and erratum, 263, page 187 (1989).

[5] K.L. Wolf, N.J.C. Packham, D.R. Lawson, J. Shoemaker, F. Cheng, and J.C. Wass (Texas A & M), "Neutron Emission and the Tritium Content Associated with Deuterium Loaded Palladium and Titanium Metals." Proceedings of the Workshop on Cold Fusion Phenomena, May 23-25, 1989, Santa Fe, NM.

[6] S.E. Jones, E.P. Palmer, J.B. Czirr, D.L. Decker, G.L. Jensen, J. M. Thorne, S. F. Taylor, and J. Rafelski, "Observation of cold nuclear fusion in condensed matter.", Nature, 338, pages 737-740 (1989).

[7] P. K. Iyengar (BARC - Trombay, India) in "Cold Fusion Results in BARC Experiments" (Fifth International Conference on Emerging Nuclear Energy

Systems, Karlsruhe, July 3-6, 1989) states in his summary: "The very high probability for the tritium branch in cold (d-d) fusion reactions would indicate processes of neutron transfer across the potential barrier as postulated by Oppenheimer over half a century ago and elaborated on more recently by Rand McNally..." (See [12]).

[8] R.A. Oriani, J.C. Nelson, S.K. Lee, and J.H. Broadhurst, "Calorimetric Measurements of Anomalous Power Produced by Cathodic Charging of Deuterium into Palladium.", Presented at the electrochemical Society meeting at Hollywood, FL, Thursday, October 19, 1989.

[9] A. Belzner, U. Bischler, S. Crouch-Baker, R.M Gur, E. Lucier, M. Schreiber, and R.A. Huggins, untitled invited paper presented by Huggins at the Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989.

[10] A.J. Appleby, S. Srinivasan, Y.J. Kim, O.J. Murphy, and C.R. Martin, "Evidence for Excess Heat Generation Rates During Electrolysis of D20 in LiOD Using a Palladium Cathode - A Micro calorimetric Study", Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989.

[11] A.De Ninno, A. Frattolillo, G. Lollobattista, L. Martinis, M. Martone, L. More, S. Podda, and F. Scaramuzzi (Centro Richerche Energia Frascatti), "Neutron Emission for a Titanium-Deuterium System.", Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989.

[12] J.R. Oppenheimer and M. Phillips, "Note on the Transmutation Function for Deuterons.", Phys. Rev. 48, 500-502 (1935).

[13] M. Wadsworth (U of Utah), "Metallurgical Aspects of Electrochemical Loading of Pd with Deuterium.", NSF/EPRI Workshop on Anomalous Effects in Deuterated Materials., Oct. 16-18, 1989.

[14] V.C. Noninski and C.I. Noninski (LEPGER, Sofia, Bulgaria), "Determination of the Excess Energy Obtained During the Electrolysis of Heavy Water.", submitted to J. Electroanal. Chem. (Copy mailed to Fusion Facts, October 25, 1989).

[15] C. Sanchez, J. Sevilla, B. Escarpizo, F.J. Fernandez, and J. Canizares, "Nuclear Products Detection during Electrolysis of Heavy Water with Ti and Pt Electrodes.", Solid State Communications, Vol. 71, No. 12, pp 1039-1043, 9989.

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B. NEWS FROM THE UNITED STATES

NATIONAL COLD FUSION INSTITUTE

The new National Cold Fusion Institute has been establishedby the University of Utah, with facilities located at 390 Wakara Way, University of Utah Research Park. Major funding (a total of $5 million) for the Institute and other cold fusion legal expenses was furnished by an act of the Utah Legislature.

In August the Engineering and Metallurgy groups moved all of their cold fusion experiments into the Institute facilities. All of the cells required recalibration and retesting so that responses to the new environment could be assessed and managed.

All cells are now running with facilities to recombine the evolved

gasses. The physics group has designed a mobile measurement unit for monitoring radiation. A routine system of periodic measurements of electrolytes for tritium are now in process. Two sets of experiments have been specifically designed to enhance tritium production.

SCIENTIFIC PROGRESS:

1. In six weeks of neutron and gamma ray measurements on four cells in the Fleischmann-Pons laboratory, the Physics group found no evidence of d+d fusion. They conclude that conventional nuclear processes cannot account for reported low levels of excess energy. No conclusions relating bursts with nuclear processes can be drawn.

2. The Engineering group has found that the flow-through calorimeters provide an accuracy in energy balance of 98.5%.

3. Tritium measurements in the electrolytes from cells having shown bursts have shown a five to sevenfold enhancements above the amount expected from concentration due to isotope separation during electrolysis.

4. Complete study of cathodes from cells which showed bursts in both the Wadsworth and Fleischmann-Pons laboratories have shown extensive migration of elements to the surface ("poisonings", some of which may be beneficial to the process). No dendrites were found. Massive dislocations in the interior of the palladium cathodes were found (far greater than those found in metals from nuclear reactors). There is general expansion of the metallic lattice.

5. Ongoing discussions with targeted agencies and corporations are continuing to make funding arrangements for future research and development.

PROPOSED ACTIVITIES:

The main objectives of the National Cold Fusion Institute are to resolve the central issues of reproducibility, mechanism, and effect on materials of the cold fusion process. Experiments are underway to enhance tritium production, to test for a variety of trigger mechanisms, and to provide materials from active cells for analysis.

Drs. Fleischmann and Pons have continued their own line of research independently of the Institute. However, the Institute's program is influenced by their oversight and advice. Fourteen faculty from the University of Utah are now involved in the research program of the Institute.

LOCAL NEWS ON COLD FUSION AT U/U:

The University of Utah Review (published by the Alumni Association) reported in their August/September issue reported the following:

"The heat buildup or energy surges range from an event several months ago in which an electrochemical cell produced seven times as much energy as was placed into the cell to a more recent event in which the energy output was about 100 percent higher than the energy input.

"Recent analysis ... on spent palladium rods show surfaces enriched with lithium, and the presence of a large number of other elements on the surfaces, including sulfur, silicon,

and rhodium. Researchers want to learn what role these and other elements are playing in producing the excess heat that is the hallmark of solid-state fusion reactions." (From an article entitled "Engineers, metallurgists push fusion studies".)

NSF/EPRI MEETING - WASHINGTON, D.C.

The NSF/EPRI WORKSHOP ON ANOMALOUS EFFECTS IN DEUTERATED MATERIALS was held in Washington, D.C. October 16-18, 1989. The purpose of the meeting was stated in the Wednesday, October 18, 1989 press release as follows:

"The anomalous effects reported in the metal-deuterium system are interesting. NSF (National Science Foundation) and EPRI (Electric Power Research Institute) decided to hold this workshop to invite scientists who have direct and related experience in the research to assess the experimental status, to identify the experimental issues, and to determine possible future research needed to clarify these issues. In this respect, the meeting has been very successful.

"New, positive results in excess heat productions and nuclear product generation have been presented and reviewed in a logical, frank, open, and orderly manner. Based on the information that we have, these effects cannot be explained as a result of artifacts, equipment or human errors. However, predictability and reproducibility of the occurrence of these effects and possible correlations among the various effects, which are common for the accepted established scientific facts, are still lacking. Given the potential significance of the problem, further research is definitely desirable to improve the reproducibility of the effects and to unravel the mystery of the observations.

"We would like to point out that a large volume of experimental data has been presented and various models proposed. Although a brief summary has been made ..., it would take time to determine specific detailed steps needed to improve the overall understanding of the effects. The Co-chairmen and the Subcommittee Chairmen will work closely with scientists in the field in the next few weeks to prepare a formal report of this Workshop to address the charge that NSF and EPRI have given to the Workshop."

A separate October 18, 1989 press release was prepared by Dr. Edward Teller (Father of the H-Bomb) as follows:

"Numerous interesting and partially contradictory results on cold fusion are in disagreement with the solidly established nuclear theory of fusion. There is a possibility to reconcile the results with the theory, assuming that the deuterons act as neutron donors with various materials (other deuterons or lithium or palladium) acting as neutron acceptors. The neutron transfer by direct exchange is prohibited by the Gamow_penetration factor, but a catalytic transfer of neutrons might be possible. It is conceivable that the catalyst could be an as yet undiscovered neutral particle.

"It is proposed that U-235 be tried as a neutron acceptor because of its great energy release and of its characteristic response to neutron absorption.One may also try to replace deuteron in its role as neutron donor by Beryllium nuclei.

"It is recommended in recognition of the high class work that yielded surprising results that the effort be supported in order to obtain clarification, whether the results are due to sophisticated difficulties in the experiments or whether a new phenomenon is involved. An example of such a new phenomenon has been proposed above without claiming that this indeed is the explanation of the results."

Attendees at the conference included the following:

ARGONNE NATIONAL LABORATORY
Dr. Kevin Myles
BRIGHAM YOUNG UNIVERSITY
Dr. Steven Jones
BROOKHAVEN NATIONAL LABORATORY
Dr. Peter Bond
CASE WESTERN RESERVE UNIV
Dr. Ernest Yeager
CALIFORNIA INSTITUTE OF TECHNOLOGY
Dr. Carlo Carraro, Dr. Nathan Lewis
ELECTRIC POWER RESEARCH INSTITUTE
Dr. Bendi Chexal, Dr. Thomas Schneider, Robert D. Weaver, Dr. David Worledge
ENGELHARD CORP
Dr. John Werth
EXON RESEARCH & ENGINEERING CO.
Dr. Patrick Grimes
GENERAL ELEC.. RESEARCH DEV. CENTER
Dr. James Bray
JOHNSON-MATTHEY TECHNICAL CENTER
Dr. David Thompson
LAWRENCE LIVERMORE NATIONAL LAB
Dr. Edward Teller
LOS ALAMOS NATIONAL LABORATORY
Dr. Toward O. Men love, Dr. Edmund Storms, Dr. Carol Talcott
MARTIN MARIETTA ENERGY SYSTEMS
Dr. Donald P. Hutchinson
NATIONAL RESEARCH LABORATORY
Dr. Scott Chubb, Debra R. Rolison, Dr. Harold Szu
NATIONAL SCIENCE FOUNDATION
Dr. Frank L. Huband, Dr. Paul Werbos
NAVAL RESEARCH LABORATORY
William E. O'Grady
PENNSYLVANIA STATE UNIVERSITY
Dr. Joseph Jordan
PURDUE UNIVERSITY
Dr. Yeong E. Kim
ROCKWELL INTERNATIONAL CORP
Dr. Nathan Hoffman
SRI INTERNATIONAL
Dr. Mike McKubre
STANFORD UNIVERSITY
Dr. Robert Huggins
STATE UNIVERSITY OF NEW YORK
Dr. Tarun K. Chaki
TEXAS A&M
Dr. John Appleby, Dr. John O'M.Bockris, Dr. Kevin Wolf
UNIV OF ARIZONA
Prof. johann Rafelski
UNIV OF CALIF - BERKELEY
Dr. K.B. Whaley
UNIV OF HOUSTON
Dr. C.W. Chu
UNIV ILLINOIS-CHAMPAIGN
Dr. Gordon Baym, Dr. George Miley
UNIV OF MINNESOTA
Dr. Richard Oriani
UNIV OF TEXAS AT AUSTIN
Dr. A.J. Bard
UNIV OF UTAH
Dr. Martin Fleischmann, Dr. Stanley Pons, Dr. Hugo Rossi, Dr. Milton Wadsworth
UNIV OF VERMONT
Dr. Ted B. Flanagan
US DEPT OF ENERGY
Dr. Ryszard Gajewski
WESTINGHOUSE SAVANNAH RIVER CO.
Dr. Khalid Mansour

About thirty papers were presented by some of the above attendees. Our sources state that two were negative (e.g. Dr. Nathan Lewis from Cal Tech) and the rest positive. One of the important papers is the Texas A&M

paper (ref [1] under the Theory article showing that tritium is definitely produced by the action of Fleischmann-Pons type cells under specific conditions. Ed).

EPRI or NSF will be publishing the proceedings of this important workshop.

ELECTROCHEMICAL SOCIETY MEETING IN HOLLYWOOD, FL.

Under the direction of the organizing chairperson (L.R. Faulkner), the following papers were presented October 19-20, 1989 at The Electrochemical Society meeting in Hollywood, FL.:

J.N. Harb, W.G. Pitt, D.N. Bennion, E.P. Palmer, J.B. Zirr, G.L. Jensen, and S.E. Jones (BYU), "Observation of Neutrons from Cold Nuclear Fusion."

M.A. Butler, D.S. Ginley, J.E. Schirber, and R.I. Ewing, "Attempts to Observe Cold Fusion in Pressure and Electrochemical Experiments."

J. Jorne and J. Toke (Univ of Rochester), "Search for Cold Fusion of Deuterium in Palladium."

R. Alqasmi, K. Albertsen, H.G. Chotka, and H.J. Schaller, "Neutrons and Tritium from Cold Fusion in Pd-D."

A.J. Appleby, Y.J. Kim, O.J. Murphy, and S. Srinivasan (Texas A&M), "Anomalous Heat Production on Electrolyzing Heavy Water Solutions of Lithium Deuteroxide with Palladium Cathodes."

R. Adzic, D. Gervasio, I. Bae, B. Cahan, and E. Yeagar (Case Western), "Investigation of Phenomena Related to D20 Electrolysis at a Palladium Cathode."

U. Landau, W.M. Lynes, D. Roha, R. Saini, and S. Rochel-Landau (Case Western), "Experiments in Search of electrochemically Induced Cold Fusion."

E. Darcy, D. Young, G. Badhwar, and A. Konradi, "Search for Evidence of Cold Fusion by Radiation Detection and Calorimetry."

S. Gottesfeld, R.E. Anderson, D.A. Baker, C.R. Derouin, F.H. Garzon, C.A. Goulding, M.W. Johnson, E.M. Leonard, T.E. Springer, and T. Zawodzinski, "Experiments in Search of Nuclear Reactions and Excess Heat in Metal Deuterides."

R.A. Oriani, J.C. Nelson, S.K. Lee, and J.H. Broadhurst, "Calorimetric Measurements of Anomalous Power Produced by Cathodic Charging of Deuterium into Palladium."

J. McBreen, "Electrolysis of LiOD in a Sealed Cell."

W.A. Adams, E.E. Criddle, V.S. Donepudi, B.E. Conway, G. Jerkiewicz, J. Herbert, C.L. Gardner, and F. Szabo, "Exploratory Experiments Concerning Anomalous Thermal Effects in the Palladium-Deuterium System."

J.W. Fleming, H.H. Law, P.K. Gallagher, J. Sapjeta, D. Loiacano, and W.F. Marohn, "Effect of Microstructure on the incorporation of Deuterium into Palladium."

H.H. Law, P.K. Gallagher, J. Sapjeta, & R. Stoffers, "Diffusion of Deuterium in Palladium."

P. Ross and H. Sokol, "In Situ Measurements of the H (D) Thermodynamic Activity and Stoichiometry in Pd during Electrolysis."

Y.E. Kim, "Neutron-Induced Chain-Reaction Processes for Electrolysis with Metal Deuterides."

R.T. Bush, and R.D. Eagleton, "A Loose Deuteron Cluster Model for Cold Nuclear Fusion."

S. Crouch-Baker, T.M. Gur, G. Lucier, M Schreiber, and R.A. Huggins (Stanford), "Comparison of Thermal Measurements on Two Fast Mixed-Conductor Systems: Deuterium and Hydrogen in Palladium."

J.W. Fleming, H.H. Law, J. Sapjeta, P.K. Gallagher, and W. Marohn, "Calorimetric Studies of Electrochemical Incorporation of Hydrogen Isotopes into Palladium."

M.C.H. McKubre, S.I. Smedley, F.L. Tanzella, and R.D. Weaver, "Calorimetric and Kinetic Observation of D2-PressurizedLiOD/D2O/PdCells."

T.R. Jow, E. Plichta, C. Walker, S. Slane, & S. Gilman, "Investigation of 'Electrochemically Induced Nuclear Fusion of Deuterium'--Heat Measurements."

M.H. Miles, K.H. Park, and D.E. Stilwell, "An Electrochemical Calorimetric Search for Evidence of Cold Fusion."

L. Redey, K.M. Myles, D. Dees, M. Krumpelt, and D.R. Vissers, "Electrochemical and Calorimetric Investigations of the Pd-D System."
V.C. Noninski, and C.I. Noninski (LEPGER, Bulgaria), "Energy Effects during the Electrolysis of D2O with Pd and Pt Electrodes."

N. Huang, Q.H. Gao, B.Y. Liaw, and B.E. Liebert, "A Flow Calorimeter used in Duplication of ' Cold Fusion' ."

R.T Bush, R.D. Eagleton, and J.F. Stephenson, "Cold Nuclear Fusion Research at Cal Poly Pomona: Some Preliminary Data."

DOE PANEL MEETING AND REPORT

The Cold Fusion Panel of the DOE's Energy Research Advisory Board has recently reviewed its July's interim report (See Fusion Facts, Vol. 1, No. 1, July 1989 cover story). On October 31, 1989 the 20-member panel approved wording on the final report that concludes that experiments thus far "do not present convincing evidence that useful sources of energy will result from the phenomena attributed to cold fusion."

The members of the panel did not recommend "any special funding for the investigation of phenomena attributed to cold fusion." Panel members, however, when interviewed cited the use of federal funds that are now being used to support cold fusion activities. It is the idea of establishing new special funding that the panel does not recommend.

The panel is sympathetic toward modest support within the current funding system. "... sympathetic toward more support for carefully focused and cooperative experiments with the present funding system," is the statement in the approved draft.

The panel agreed that "Nuclear fusion at room temperatures wouldbe contrary to all understanding gainedof nuclear reactions in the last half century. ... It would require the invention of an entirely new nuclear process."

The preamble to the report states, "Ordinarily, new scientific discoveries are claimed to be

consistent and reproducible; as a result, if the experiments are not complicated, the discovery can usually be confirmed or disproved in a few months ....

"The claims of cold fusion, however, are unusual in that even the strongest proponents of cold fusion assert that the experiments, for unknown reasons, are not consistent and reproducible at the present time. However, even a single short but valid cold-fusion [demo] would be revolutionary.

"As a result, it is difficult to resolve all cold-fusion claims since, for example, any good experiment that fails to find cold fusion can be discounted as merely not working for unknown reasons. Likewise, the failure of a theory to account for cold fusion can be discounted on the grounds that the correct explanation and theory [have] not been provided. Consequently, with the many contradictory claims, it is not possible at this time to state categorically that all the claims for cold fusion have been convincingly either proved or disproved ....

"Based on these many negative results and the marginal statistical significance of reported positive results, the panel concludes that the present evidence for the discovery of a new nuclear process termed cold fusion is not persuasive."

Editor's Note: The major problems in cold fusion research continue to be the difficulty of replicating some of the observed phenomena, especially the bursts of energy-producing activity. The difficulties are similar to the early days of semi-conductor technology and will be resolved in the same fashion- by dedicated scientists developing and conducting clever experiments to isolate important parameters. See the report in this issue on the work being done at the National Cold Fusion Institute.

MISCELLANEOUS REPORTS

UNIV OF CALIF - SANTA BARBARA
From Keith Henson, San Jose, CA

Prof. Roger C. Millikan, Department of Chemistry, University of California Santa Barbara describes his group's latest work on cold fusion (see Usenet/physics.fusion).

Millikan and associates have been experimenting with Fleischmann-Pons type cells using 0.1 mmPd wire in the form of a cylindrical cage about 1 cm. by 2 cm. Anode is platinum mesh. Electrolyte is heavywater and lithium deuteroxide. Bursts of radiation are being detected by the use of six 3He tubes. Results have been largely non-reproducible and difficult to explain. New cells are being charged by running for eight days with relatively low voltage and current and results are more predictable.

THEORY RAISES PROBABILITY OF DEUTERIUM TUNNELING

Gerald Rosen (Dept of Physics, Drexel Univ), "Deuterium nuclear fusion at room temperature: A pertinent inequality on barrier penetration."

J. Chem Physics volume 91, No. 7, 1 October 1989 pages 4415-4416. Rosen writes, "The apparent magnitude of the observed d-d fusion rate (for Fleischmann-Pons, and Jones experiments - References 4 and 6 of Theory article above), roughly has a required 10^{-20} per second or about 10^{-19} per second for the $d + d$ --> 3He + n or T + p, may result from the quantum mechanical tunneling

Of deuterons through the molecular Coulomb barrier in vibrational excited deuterium molecules that are trapped and aligned interstitially in a porous octahedral metallic lattice ...
Letter points out that a linearly vibrating D2 molecule that is strongly caged in an octahedral metallic lattice site couldbe expectedto have a probability of fusing (tunneling) that is close to the computed range of values based on current cold fusion experiments.

SCREENING OF PROTON AND DEUTERON CHARGES
(Courtesy of Dr. Art Collins)

Adam Burrows (Dept of Physics & Astron. Univ of Ariz), "Enhancement of cold fusion in metal hydrides by screening of proton and deuteron charges.", Physical Review B. Vol 40, No. 5, pages 3405-3408, 15 August 1989.

This paper describes the dramatic changes in the rate of deuteron fusion as a function of deuteron separation allowed by the screening. A table of values for deuteron fusion rates is provided for deuteron screening lengths ranging from 0.50 Angstrom to 0.01 Angstrom. The deuteron fusion rates range from 0.15 x 10^{-110} up to 0.52 x 10^{-8} deuteron pairs per second. This paper and the Rosen paper above provide some serious considerations for possible environments that will explain the observed Fleischmann-Pons excess heat.

One of the references in Burrows article is the following:

Harald Bottgerand, Valerij V. Bryksin, Hoppinq Conduction in Solids. Academic-Velag, Berlin,-1985. This book cites hundreds of references in the treatment of electrons and charged particle movement in solids. Each type of conduction is treated in mathematical detail. It is the opinion of the Editor of Fusion Facts that Bottger andBryksin could provide some insights into the phenomena of charged particle conduction in palladium lattices. We have written to Bottger and Bryksin and will share their responses with our readers. Hal Fox, Ed.

MISCELLANEOUS ARTICLES:

Robert Pool, "Will New Evidence Support Cold Fusion?", Science, Vol. 206 page 246.

Robert Pool, "Teller, Chu 'Boost' Cold Fusion.", Research News, 27 Oct. 1989, page 4 4 9.

P.M. Richards (Sandia), Molecular-dynamics investigation of deuteron separation PdD1.1.", Physical Review B, Vol 40, No. 11 15 October 1989 pages 7966-7968. [Paper reports modeling under favorable conditions for the shortest d-d distance to explain anomalous fusion reactions. The conclusion is that classical physics fails to explain the high rates of fusion that could account for observed F-P Effect.]

A.A. Shihab-Eldin, J.O. Rasmussen, M. Justice, and M.A. Stoyer (Lawrence Berkeley Labs, U. Calif-Berkeley), "Cold Fusion: Effects of Possible Narrow Nuclear Resonance." Modern Physics Letters B, Vol 3, No. 12 (1989) page 965-969. [The influence of a possible and as yet undiscovered narrow resonance in 4He on the d-d fusion rate near threshold is examined. A qualitative discussion of the structure of the lowest four O+ states and its impact on the

partial widths of decay channels is presented.]

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C. FUSION NEWS FROM ABROAD

TITANIUM FRACTURE YIELDS NEUTRONS

The following letter appeared in the 12 October 1989 issue of Nature in the Scientific Correspondence section: B.V. Deryagin, A.G. Lipson, V.A. Kluev, D.M. Sakov, and Y.P. Toporov, "Titanium fracture yields neutrons?", Nature, Vol 341, 12 October 1989, page 492. (Includes 8 references.) The correspondence describes an experiment in which neutrons are released when titanium chips are fractured mechanically in a heavy ice and lithium deuteride environment. The experiment found that neutron counts increased by cooling in liquid nitrogen.

One of the references cited is the following: B.V. Deryagin, V.A. Kluev, A.G. Lipson, and Y.P.Toporov, "Possibility of Nuclear reactions During the Fracture of Solids." Institute of Physical Chemistry, Academy of Sciences of the USSR, Moscow, Translated from *Kolloidnyi Zhurnal*, Vol 48, No. 1, pp 12-14, January-February 1986. Original article submitted October 21, 1985. (UDC 539.375:539.1). (Includes 10 References.) In this article, the authors discuss the measurement of neutrons by the fracture of heavy ice being struck by a metal striker accelerated in the barrel of a gas gun.

BULGARIA JOINS FUSION CLUB

We were preprint to receive a delighted of the following article:

V.C. Noninski and C.I. Noninski (LEPGER, Sofia, Bulgaria), "Determination of the Excess Energy Obtained During the Electrolysis of Heavy Water.", submitted to J. Electroanal.Chem (Copy mailed to *Fusion Facts*, October 25, 1989).

The abstract to the paper states: Significant excess specific power is obtained during the electrolysis of d20 although a Pdcathode of thin wire (0.05 cm. diameter) is used, in which case a relatively low value of the excess energy is expected. The method and arrangement applied remove the main causes for inaccuracies when determining the energy in question. Thus the possibilities and the perspectives to use the said energy in practice seem to be greater than some researchers are inclined to consider, especially when the technology is in the stage of initial investigations.

Dr. Noninski's diagram of the experimental arrangement is provided below:

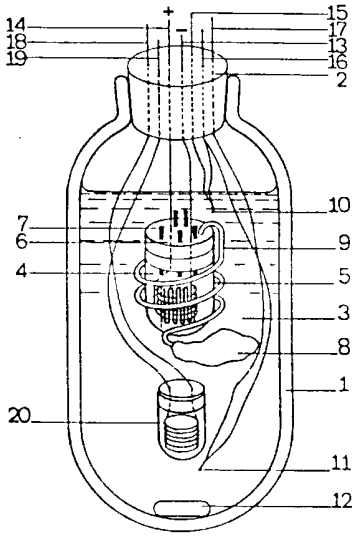

FIG. 1

Note that the entire experimental fusion cell is enclosed in a water bath within the confines of a large Dewar flask. Item 12 is a magnetic stirrer. Items 10 and 11 are thermocouple. Item 20 is a calibrating electrical resistor. Item 8 is an elastic bag (balloon) used to capture all evolved gases. The entire unit can be carefully calibrated by introducing a carefully measured amount of energy into the resistor and measure the temperature rise.

During operation of the fusion cell, all energy is captured in the Dewar container and creates a heat rise that canbe comparedto the calibrated heat rise. The end result is a self-contained unit that removes many of the sources of heat loss that would otherwise have to be considered. The experimental results show a typical (similar to other experimenters) wide range of excess specific heat. In ten experiments the excess specific rate of heating values ranged from 1.66 to 41.4 watts per cubic centimeter of Pd cathode.

Editor's Note: This is the nicest arrangement for a solid-state fusion experiment for excess heat that we have seen. We especially recommend this arrangement for student experimental work. We are grateful to Drs. Noninski for sharing their work with us. Ed.

SPAIN REPORTS TRITIUM PRODUCTION WITH TITANIUM
(Courtesy Dr. S.P. Faile)

C. Sanchez, J. Sevilla, B. Escarpizo, F.J. Fernandez, and J. Canizares, "Nuclear Products Detection during Electrolysis of Heavy Water with Ri and Pt Electrodes.", Solid State Communications, Vol. 71, No. 12, pp 1039-1043, 1989. [Authors use a Ti cathode, Pt anode, heavy water with $Li2SO_4$ as an electrolyte. After a charging time of about five days, bursts of neutrons are recorded followed by an increase in tritium measurements. The conclusion states: "...the observations reported are compatible with the existence of cold fusion processes. However, the underlying theoretical mechanism is still unknown. The process has an incubation period of about five days and we have not yet been able to pinpoint the exact conditions under which it occurs. Although the threefold type of observations leave little doubt as to the existence of the phenomena, reproducibility still remains poor. "]

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D. HISTORY SPECULATION ON FUSION
(Courtesy of Dr. Kerry Lane)

Flash News (from the past): New York Times, March 27, 1927, “HYDROGEN TRANSMUTED INTO HEAVIER ELEMENT

Helium Is Produced by Two German Scientists From the Lighter Gas but in Small Quantities --A process Which Releases Stores of Energy.

"...Now, however, comes word that two scientists working in the Chemical Institute of the Berlin University, Dr. Paneth and Dr. Peters, have succeeded-in changing the lightest of all elements, hydrogen, into the next lightest, the gaseous helium .... "
"The Process Employed. In the old days of gas lamps, the so-called 'self-lighters' were very popular. They were made of a kind of platinum sponge, and when the gas was turned on

and streamed through the platinum, its hydrogen content mixed so actively with the oxygen contained in the atmosphere that sufficient heat was induced to ignite the gas .... This consideration induced Paneth and
Peters to select palladium, a metal similar to platinum, for their investigations. When they subjected hydrogen for the space of several days to the influence of finely distributed palladium -- to a palladium sponge 'they found that helium resulted -- in very small quantities, to be sure, but undeniably present .... "

"Helium for Airships. The great scientific significance of these experiments throws their practical significance in the shade, and yet this is by no means non-existent. To be sure, the quantities of helium thus far created have been extraordinarily minute, but once the bridge has been thrown over to-this hitherto unknown territory, then it is probably only a question of time before the narrow way is widened and strengthened .... "

"A point of especial significance, as Professor Kirchberger points out, is the following: In building up the helium atom from the hydrogen atom vast volumes of energy must be set free, which could be employed either as heat energy or as radiative energy. The infinitesimal quantities of helium so far developed have not permitted the presence of this energy to be proved. This will be possible only when the quantities developed become greater. Since energy has an immediate economic value, the importance of the experiments in this direction cannot be estimated for the moment. One may imagine that the entire problems of heating and lighting, two fundamemental questions of modern man's existence, may be revolutionized by this discovery."

Dr. Lane included a copy of part of an article from an unidentified source:

"It is not certain where the idea of transporting nuclear weapons with missiles first appeared. It was not the Germans who had the idea. German nuclear physics before and during the war was neither consciously, nor actively, working towards nuclear weapons."

Then Dr. Lane calls our attention to the well-documented (even a movie was made about the exploit) destruction of a Norway heavy water plant by the Allies near the beginning of World War II (but after the Nazi forces had taken over Norway).

The Speculation: Could it be that Paneth and Peters worked under the Nazi regime in the development of processes for making energy from heavy water? *Nature* was kind enough to print a complete withdrawal of Paneth and Peters earlier claims. See Nature, Vol. 119, pgs 706-7, (1927).

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E. FUSION IMPACT ON AGRICULTURE

BACKGROUND

The combination of farming together with measures to improve health and conquer disease has resulted in a population explosionandanincreasing demand for greater food production. The following table shows how the population has changed since 1650:

YEAR	YEARS TO DOUBLE	WORLD POPULATION
1650	200	500,000,000
1850	80	1,000,000,000
1930	45	2,000,000,000
1975	35	(ESt.)4,000,000,000
2010	?	8,000,000,000

AS shown by the table it took 200 years (from 1650 to 1850) for the population of the worldto double from 500 million to one billion. The next doubling (from 1850 to 1930) required only 80 years as the world began to change from using wind, animal, and human power for food production to the use of machinery. The world population of 2 billion doubled to 4 billion in just 45 years (from 1930 to 1975). During this time period a great energy revolution in agriculture was achieved, especially in the United States.

Today the world's food production comes from the plants and animals of land and water in the following percentages:

Food from land	98%
Food from oceans and water	1%
Food from plants	92%
Food from animals	7%
Food from 8 basic grains	52%

THE CURRENT FOOD PROBLEM

The food problem is a combination of agriculture, distribution, and politics. In drought-stricken Africa, millions have died from the combination of lack of food and from political leaders not allowing food to be distributed to competing tribes. Some areas face periodic surpluses in some crops. Other areas face periodic droughts or floods that damage crop production.

There is little that new energy sources can do for food problems stemming from political decisions. However, there is much that new energy sources can do for the improvement of agriculture. Those means of improvement are discussed following a brief history of improvements that have been made and problems that still exist.

IMPROVEMENTS IN AGRICULTURE

One of the greatest methods of improvement that we tend to emphasize has been the development of agricultural machinery. We cite the iron-bladed plow, the McCormick reaper, the cotton gin, the hay-mowing machine, the tractor, and on to today's automated lettuce-packing equipment and fruit-picking machines. Another great improvement has been the development of better seeds and plants. Some of these have been hybrid corn, high-protein rice, dwarf high-protein wheat, and improved fruits and vegetables. In addition, there have been improvements in poultry, cattle, pigs, and milk production through improved breeding techniques.

Other agricultural improvements have been achieved by the use of chemical fertilizers. A century ago, we began to learn to rotate crops so that nitrogen-replenishing crops were rotated with nitrogen-depleting crops. After the discovery that the major plant macronutrients, nitrogen, phosphorous, and potassium (NPK) could be manufactured and spread on our lands, anagricultural revolution took place. Crop yields increased dramatically. The combination of improved seed and the use of chemical fertilizers increased the per acre harvest of corn (maize) 251%.

Now billions of tons of phosphates, potash, and nitrogen-bearing chemicals

are now being poured out on the land.

These improvements have not come without some cost. To some extent, some of these agricultural chemicals are being washed into our waterways and destroying fish production.

Still further improvements in agricultural production have been in insect control. The seagull is Utah's state bird because the seagulls flocked in and ate millions of Mormon crickets that were destroying the crops in the early days of settling the West.
Now we use millions of gallons of pesticides, herbicides, rodenticides, and insecticides to preserve more of the crops for harvest. Again, this change has had a cost. These chemicals have killed many beneficial insects (we now import bees to pollinate fruit orchards and alfalfa fields). In addition, the washing of these chemicals into the waterways have added to pollution and destruction of aquatic life.

Irrigation, contour plowing, wind breaks, alternating row crops with pasture or alfalfa fields have been additional means by which we have modified the environment to improve agriculture. Irrigation has expanded to the use of large aquifers until, in some areas, the aquifers have been depleted faster than nature can replenish the water. In other areas large dams and miles of canals have been built to provide water to desert areas. The large inland valleys of California are examples. Water from the Colorado and the Sacramento rivers now help to produce a large fraction of the vegetables and fruits produced in the United States.

In much of our improvement in agriculture inthe United States there has been a large increase in the use of energy. For example, the energy cost of a head of lettuce delivered to a New York grocery store is estimated to be about seven times the energy value of the lettuce (or other food). If the rest of the world used as much energy to grow and transport food as we do in the United States, the world's consumption of energy would have to be greatly increased. All of the above improvements have contributed to changes in our environment.

AGRICULTURAL IMPACT ON ENVIRONMENTAL POLLUTION

Currently two main sources of pollution that stem from the increases in the growing of food and fiber are the burning of forests to create more agricultural land, and the pollution by the washing of agricultural chemicals into our streams, rivers, lakes, and oceans.

Satellite pictures taken at night over Brazil (and other developing nations) show enormous areas of burning forests. The growing populations of the world's nations must be fed and people do not eat tree leaves. Therefore, just as we in America destroyed a continent of forests to produce the vast farmlands of our midlands, so too do other nations destroy their forests to provide more land to grow crops.

Another source of less toxic pollution is the gradual eroding of our agricultural lands by wind and water. This top soil often ends up in the streams, rivers, and lakes and either fill up behind dams or are carried to the river mouths and build up the ocean deltas. The mighty Mississippi carries millions of tons of top soil from the heartland of America to build deltas in the Gulf of Mexico. The

Amazon is carrying scarce soil from agricultural lands that were once Brazilian rain forests. All around the world the water and the winds are removing soils and the deserts, in many places, are encroaching on arable lands.

AREAS OF IMPROVEMENT

In addition to the continued improvements in seeds, plants, farming practices, fertilization, and insect control, there are other areas for improvement. Initially, it is important to improve agricultural practices in all areas of the world. This step involves education and education usually improves with an improvement in the standard of living. Energy is the. key to these kinds of improvements. The important factor is not just more energy but the expansion of low-cost non-polluting energy. This is the area in which solid-state fusion can strongly contribute.

Low-cost energy can be used as a replacement for wood as a fuel. The increased use of solid-state fusion energy could lead to less destruction of forests and watersheds. The restoration of watersheds can become practical. The result, in some areas, would be a reduction in the loss of agricultural lands due to periodic floods.

Low-cost energy can be used for building of dams and the distribution of stored water to arid lands. In addition, low-cost energy can be used to remove contaminating salts from brackish water or even the desalination of sea water to create agricultural water. Where river water is plentiful, low-cost power can be used to supplement rainwater with irrigation systems. Low-cost energy can be used to power both stationery and mobile agricultural equipment. The combination of solid-state fusion reactors and space-agebatteries could find *an* excellent application in agricultural equipment. See Reference [2].

As the world's population continues to increase, more agricultural land will be required. Borlaug and Dowswell [1] make the following statements: "The only long-term solution is sustained agricultural development in areas where food is in short supply." Again they state, "There are two aspects to the problem of feeding the world's people. The first is the complex task of producing sufficient quantities of the desired foods to satisfy people's needs. The second task, equally or even more complex, is to distribute the food equitably. The chief impediment to equitable food distribution is poverty -- lack of purchasing power resulting from unemployment or underemployment, which, in turn, is made more severe by rapid population growth. We feel that only by increasing agricultural productivity in food-deficient areas can both aspects of the world food problem be ameliorated. Further, we are convinced that science-based, high-yielding, sustainable agriculture is the key to the required increase."

Food is in short supply in drought areas, in some cold climate areas, in post-disaster areas, and in areas suffering from low agricultural productivity. Low-cost energy coupled with suitable education can be the means by which agriculture can be improved in these areas. In drought areas, low-cost energy can help provide additional agricultural water. In cold climates, low-cost energy can be used to prolong the growing season

or even to replace field crops with crops grown under plastic or glass.

In many countries, where they are striving to become more industrialized, the wealth of the country is often exchanged for energy imports. For example, in Kenya, the 1986 import expenditures were 26,711,310,000 Kenyan shillings. Of this amount 17.9% or about 4,781,320,000 Kenyan shillings were used for the import of crude petroleum. At the same time the balance of payments was a negative 9,063,000,000 Kenyan shillings. In other words, half of the entire negative balance of payments was for petroleum. If Kenya could supplant all or part of that massive outflow of scarce funds by the use of solid-state fusion energy, then some of those funds could be diverted to education and the improvement of agriculture. Source: Reference [3].

PROJECTED IMPROVEMENTS

Assuming that the electrical power from solid-state fusion is practical and lower in cost than power from fossil-fuel power plants, then the impact on agriculture can be highly beneficial. The following trends toward improving agriculture and the distribution of food are forecast:

1. Low-cost energy will be used to store, .distribute, and process water so that the agricultural lands are retained or protected from the periodic damage by wind and water and to increase crop yields.

2. Low-cost energy will be used to process brackish or salt water for agricultural use in reclaiming lands lost to the desert.

3. Agricultural products will be grown in less temperate regions of the world with a reduction in food transportation costs and a reduction in the associated transportation pollution.

4. Low-cost energy will make it practical to dredge the rivers and reclaim the soils and restore it to agricultural lands.

5. Remotely sited solid-state fusion power plants will be sources of waste heat that will be used for the promotion of food production, probably under greenhouse conditions.

6. Home and industrial greenhouses will become practical. The increase in local gardening will decrease transportation pollution and decrease the demands for more agricultural developments.

7. The processing of home sewage at high temperatures (to destroy disease-causing micro-organisms) will increase and the residue be used for agriculture purposes.

8. Stringent laws will be passed to prevent the pollution of rivers, lakes, and oceans. National waterways will be restored to more pristine conditions and natural aquatic life will again inhabit dead rivers, lakes, and seas. Commercial fishing will be restored in vast areas such as some coastal regions of the U. S. and Europe.

9. Improved agricultural practices involving the principles of organic gardening and farming will become widespread. The use of chemical fertilizers in highly developed counties will decrease with the resulting decrease in the pollution of some of the world's rivers and

lakes. This will lead to an increase in water-grown food.

10. Low-energy costs will lower the cost of fertilizers. In developing countries where chemical fertilizers are badly needed there will be an increase in the use of these fertilizers.

11. Planting and watering of new woods and forests will be encouraged. The result will be the trapping and containment in growing trees of atmospheric carbon dioxide andof some atmospheric pollutants. The trees will also produce oxygen. In addition, the restoration of watersheds will help prevent flood damage to agricultural lands.

12. Large sources of underground brackish water will be processed for agricultural purposes. Some desert lands will be restoredtoproduction.

13. Low-cost energy will be used for desalination projects and the potable water will be pumped to nearby lands for agricultural uses.

14.The decrease in the burning of fossil fuels will reduce the amount of sulfur in the atmosphere which will result in an increase in the need for the production and application of agricultural sulfur. Sulfur is an important ingredient in amino acids.

15. Both stationary and mobile farm equipment will be developed that will be poweredby solid-state fusion power plants.

16. Energy-intensive food-preparation and transportation costs will decrease with the widespread use of solid-state fusion energy.

17. Low-cost energy will help to increase agricultural productivity which will free people for work in other activities. The result will be an increase in the standard of living.

18. Oil-rich desert countries will either apply low-cost energy to the restoration of desert lands to agricultural use ortheywill increase their imports of foods from other countries.

19. As food supplies increase, population will increase. Some agricultural land will be used for dwellings, offices, and factories. This land use will increase the need for the development of marginal lands for agriculture.

20. Many of the irrigated lands that have become overly alkaline (due to the addition of mineral-rich water, the evaporation of the water, and the soil retention of mineral salts) will be reclaimed. Low-cost energy will be used in a combination of desalination, water flooding, and water treatment to restore such lands. (Examples are found in some of the California valleys.)

21. Low-cost energy will be used to modify the environment such as in the use of heaters for orchards or heaters for soil to extend growing seasons.

22. Because the limits to plant growth is the availability of carbon dioxide and not the amount of light, energy will be used to process carbon dioxide for increasing growth, especially in greenhouses.

23. Energy will also be used to extend illumination, especially in greenhouses and especially to supplement sunshine in winter and in extreme latitudes.

REFERENCES:

[1] Norman E. Borlaug and Christopher R. Dowswell, "World Revolution in Agriculture.", 1988 Britannica Book of the Year, Encyclopaedia Britannica, Inc. Chicago.

[2] "Fusion Impact on Automotive Industry.", FUSION FACTS, Vol. 1, No. 3, September, 1989.

[3] "Kenya.", 1989 Britannica World Data in 1989 Britannica Book of the Year, page 635.

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F. SPECIAL WARNING TO EXPERIMENTERS

One of the scientists, with whom we share information, reports on the following:

Reaction by-products from Fleischmann-Pons Cells can "run away" in the sense that the electrolyte is ejected from the cell. If you are working with cells toproducetritium, special precautions should be taken. One such accident has occurred in which nearby workers were sprayed with tritium-containing liquid. While radioactivity from tritium is easy to guard against, the ingestion of tritium into the body is to be avoided. Tritium may cause severe damage, even birth defects, if it ends up in body reproductive cells.

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G. COLD FUSION BIBLIOGRAPHY

The Fusion Information Center, Inc., publisher of FUSION FACTS has agreed with Dr. Samuel P. Faile to publish his FUSION ANNOTATED BIBLIOGRAPHY on computer media.

Dr. Faile began reading and annotating all available articles on cold fusion immediately after the March 23, 1989 announcement by Fleischman and Pons. Three volumes (sized for publication on 5 1/4 inch diskettes) are now available.

Each volume is supplied with the INFOFIND search and retrieval program. Information retrieval is available by entering any non-trivial word including authors names, publications, or institutions.

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